TIDAL SYSTEM

Ferdinand Jacobs,

OF

DRAINAGE,

FOR

THE UPPER WARDS

OF

CHARLESTON, SOUTH-CAROLINA,

BY CHARLES PARKER,
CITY SURVEYOR.

CHARLESTON:
PRINTED BY A. E. MILLER,
No. 3, State Street.
1853.

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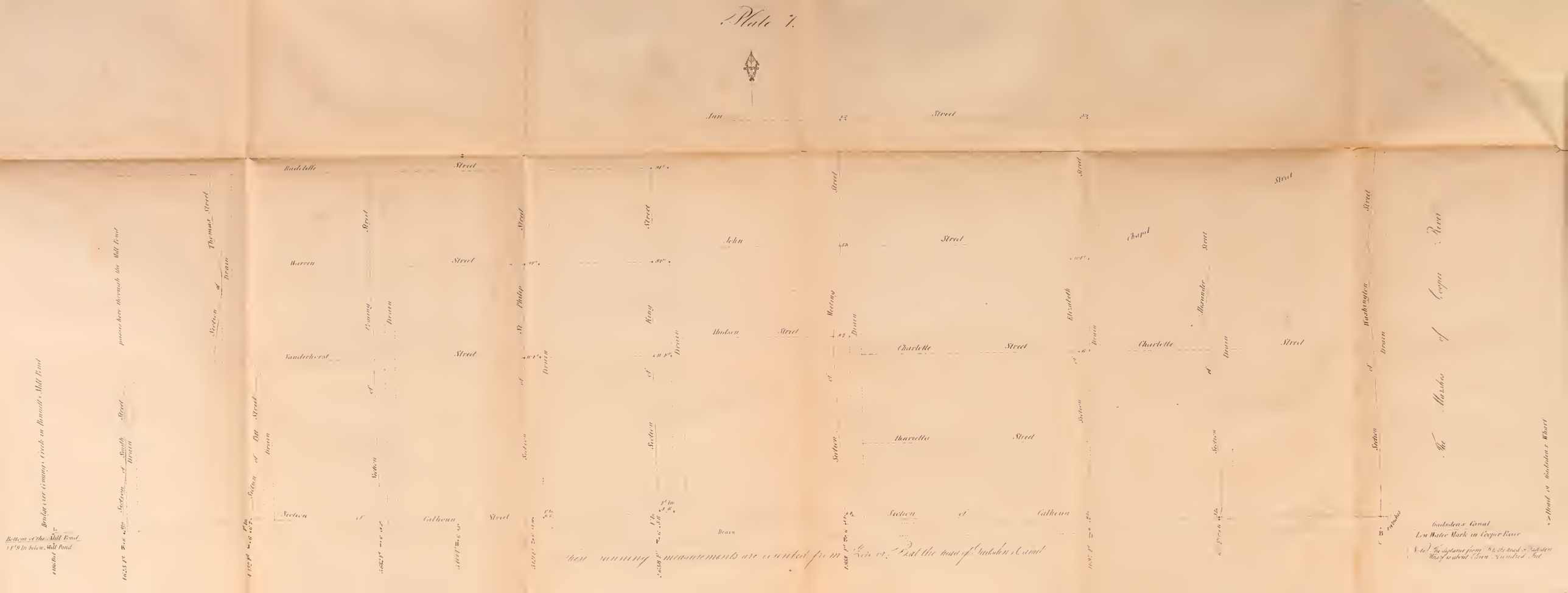
Plate 7.


Ann
Street
Radcliffe
Warren
Vanderhorst
Section of Pitt Street
Section of Calhoun Street
Section of Thomas Street
Section of Pitt Street
Section of Calhoun Street
Section of Philip Street
Section of Calhoun Street
Section of Calhoun Street
Section of Calhoun

Revd. Ferdinand Jacobs.
With the Author's Respects

TIDAL SYSTEM

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SYSTEM OF DRAINAGE.

The drainage by sewers of the *Lower Wards* of the city having proved very inefficient, and as a considerable portion of the neck, now constituting the *Upper Wards*, has been lately annexed to the city, it has been deemed advisable to propose some system, by which, drains, that may be constructed from time to time, though separate and detached at first, may ultimately become portions of a general plan, forming a combination, by which they might be made subservient to the cleansing of each other.

In early times the drainage of the *Lower Wards* was commenced by laying a deep drain in East-Bay street, between Queen and Tradd, from which others extended up Queen and Tradd, as far westwardly as King, additional ones branching therefrom. These drains were deep, and their vents into Cooper river were from one to two feet above low-water mark, ascending by inclined planes westwardly into the city. The neck of land, however, on which Charleston stands, is too flat for such a system, and, consequently, sufficient inclination could not be given to these drains, which depended entirely on rain to wash them out; and as currents would only occasionally be formed in these drains by heavy rains, frequently at long intervals, they fill up and

require cleaning out by hand, which can only be effected by breaking up the pavements, incommoding the public, and incurring considerable expense.

It is evident, that one of two systems must be adopted; that of *inclined planes*, or the other, which may be termed the level or *tidal;* and as the former is *impracticable*, resort must be had to the latter.

The impracticability of the former system is best shown by reference to a diagram *(Plate* 1.*)* by which it appears that Charleston is not sufficiently elevated to admit of such a system. The diagram may be thus explained:—It consists of the profile of Calhoun-street from Gadsden's canal to Bennett's mill-pond, showing the undulating surface of the street. From Calhoun street, running northwardly into the Upper Wards, are the sections of other streets extending to Radcliffe, Ann, and Chapel, embracing a district sufficiently extensive for elucidation. The dotted lines represent drains about 6 feet high from the bottom to the crown, leaving in the clear, about 5 feet, a dimension that seems advisable for the admission of workmen. The bottom of these drains, which is here drawn *on the same level throughout*, is placed at 14 inches, or say one foot above the low-water mark of mean tides, to allow for clean drainage during three hours at low-water; so that the crown of the drains will be about 7 feet above low-water mark. A will be considered the edge of Cooper river channel at the end of Gadsden's wharf, and B the head of Gadsden's canal, the distance from A to B being 1100 feet, at which point, B, the present drain in Calhoun-street vents. From B the running measurements commence as denoted by figures, which give the

distance of various points up Calhoun-street to the bridge over Coming's creek in Bennett's mill-pond.—The depth of the crown below the surface of the streets is given in feet and inches; and it will be observed, that at several points the crown crops out.

Having described the nature of the diagram, a clear understanding of it, connected with other facts derived from experience, will demonstrate conclusively, that any plan of drainage for Charleston, based on a system of *inclined planes for sewers*, will prove abortive, because the elevation of Charleston neck above the adjacent rivers is not sufficient to admit of such a system.

Mr. G. Drysdale Dempsey, Civil Enginer, in his Treatise, (one of the best on the London sewers), says, page 100: "We have seen that Metropoliton sewer practice has recognised a fall of half an inch in 10 feet, or 5 inches in 100 feet, as sufficient for all purposes of good drainage. But preferring to allow double this fall as proportionally improving the system, by aiding the discharge, we should require a fall of 10 inches in every 100 feet."

Now it is apparent from this language, that Mr. Dempsey is not satisfied with a fall of 5 inches in 100 feet, even in London, which is well supplied with water by pipes, and is desirous of having double that fall.—We may therefore rely on the fact, that 5 inches fall per 100 feet, is the least that will suffice, even with the assistance of pipes. We know this to be so from our own experience.

Calhoun-street drain from Meeting-street to Gadsden's canal, has a descent of 2½ inches per 100 feet; a vast deal of water passes through it, viz: the Anson and

Meeting-street drains discharge into it, besides all the waters that descend in Calhoun-street from King to Meeting, from George and Hutson in Meeting to Calhoun, from Chapel down Elizabeth to Calhoun, from Charlotte down Alexander to Calhoun, and from other sources; yet still, this drain in Calhoun-street is always foul, and requires cleaning by hand. But to give a just idea of what half an inch fall in 10 feet, or 5 inches in 100 feet, is, let any one observe the side gutters in Meeting-street, between Broad and Market streets (which have that descent) during a rain or immediately afterwards, and unless the rain has fallen very fast and heavily, so as to flood the street and create a head of water, there will be no semblance of a rapid stream. My own experience and observations for many years confirm Mr. Dempsey's opinion on the subject, viz: that 5 inches fall, per 100 feet, is the *least* that will answer, even with the aid of pipes, and that double that quantity would be desirable. But let us apply even this *least* fall of 5 inches per 100 feet to Charleston neck, and see the result.

To treat this subject properly we must commence at the point A, the edge of Cooper river channel, which eventually must be the point of discharge. Then from A to King-street, which is on the very summit of the ridge, the distance is 1100 + 2658 = 3758 feet, as per diagram, which at the rate of 5 inches per 100 feet, amounts to 15½ feet. Now the summit at the intersection of King and Calhoun, is only 6 + 8. 8 = 14 ft. 8 in. above the bottom of a level drain, as appears by the diagram, consequently by ascending from A at the rate of 5 inches per 100 feet, the drain would become elevated by 15½

feet, that is, the bottom of the drain would be nearly one foot above the surface of King-street, and consequently the crown of the drain would be 7 feet above the surface of the street, instead of being at least 3 feet beneath it, showing a deficiency in height on the summit of the ridge at King-street of 10 feet. But this would not be the extent of the difficulty, for instead of assuming the point or summit F at King-street, the proper point for calculation would be the surface of Calhoun-street, at the valley H, which is about equidistant from both rivers.

Now this valley H is a fair average elevation for calculation, for as may be seen by the diagram, others are still lower, and the lands are high on both sides, east and west.

The surface of Calhoun-street at H is only 9 feet above the bottom of the *level drain, as per diagram,* and the distance from A to H is (1100 + 3400)=4500 feet, and by ascending from A, at the rate of 5 inches per 100 feet as before, the bottom of the inclined drain would be nearly 19 feet above the bottom of the level drain, that is the bottom of the inclined drain would be 10 feet (19–9) above the surface of Calhoun-street at H, and consequently the crown would be 16 feet (10+6) above the surface, instead of being 3 feet beneath the soil, showing a deficiency at H (College-street) of 19 ft. in elevation.

Again.—The Calhoun-street drain between Meeting street and Gadsden's canal has, as before stated, an inclination of 2½ inches per 100 feet, which is known to be *much too little.* Now, commencing at A, ascend to

H at that rate, and as $2\frac{1}{2}$ is the half of 5, so $9\frac{1}{2}$ is the half of 19 feet. The bottom of such a drain therefore, would be $9\frac{1}{2}$ feet above the bottom of the level drain at H; that is, the bottom of this drain ascending from A, at the rate of $2\frac{1}{2}$ inches per 100 feet, would be half a foot above the surface of the ground, and the top or crown, $6\frac{1}{2}$ feet above the ground, instead of being at least 3 feet under it, showing a deficiency in elevation of $9\frac{1}{2}$ feet.

Mr. Dempsey says p. 100, "And preserving 5 feet above the head of the main sewers, &c. . . . . These 5 feet will usually be found sufficient to allow all necessary fall in house drains and in branch sewers, to serve the superficial draining of the intervening district."—That is, Mr. Dempsey requires 5 feet, where, in the foregoing calculations 3 feet only have been allowed, for yard-drains, for sub-soil drainage of squares, for the protection of the crown, and for other purposes.

Mr. Newman, one of the Surveyors of the Surry division, in evidence before a parliamentary committee, stated, that when the situation will admit of ample fall and depth of sewer, there should be at *least* 3 feet of depth between the upper part of the crown of the arch and the surface of the road.

In adopting 3 feet in the foregoing calculations, I have done so, not because it was preferable to 5 feet, as recommended by Mr. Dempsey, but for the best of all reasons, viz: the elevation of the flat bottoms or vallies will not admit of it; but when, in crossing the summits we pass 5 feet or more below the surface of the street, it will prove the more advantageous.

It is unnecessary to say more on this subject, as it has been clearly shown, that Charleston Neck is not sufficiently elevated to admit of a system of sewers constructed on *inclined planes.* Our only alternative is the *Tidal* System, of which we now propose to treat.

THE TIDAL SYSTEM.

A TREATISE on this System necessarily involves a knowledge of the tides in the harbour and rivers at Charleston; in order to determine the proper level on which the sewers should be constructed.

With a view to the improvement of the sewers in the *Lower Wards*, the City Council caused an examination to be made in 1837. My report on that occasion is too voluminous to insert in full, but the following extracts will suffice.

To His Honor the Mayor
and Aldermen of Charleston:
Gentlemen,

In pursuance of a resolution of Council, and directions from his Honor the Mayor, to the end, that observations be made, and levels taken, to afford the necessary information for the construction of drains in Charleston on a general and efficient system—I beg leave to report:—That understanding it was the general impression, that the flood and ebb tides made about an hour sooner in Ashley than in Cooper river, and that the respective heights of these rivers were different at high and low-water, it became necessary to ascertain whether such were the facts, and if so what were their

respective differences. With a view to this investigation, inquiries were instituted.

John Kane, who for thirty years past has been rafting timber from Chisolm's mill and Wappo creek, at the west end of Tradd-street and opposite thereto, round White-point to Hamilton and Co's. wharf at the east end of Tradd-street and to other points on Cooper river, says: That he has floated rafts down Ashley river with first ebb round White-point into Cooper river, and there found the vessels riding flood. Other persons well acquainted with the currents of these rivers corroborate John Kane's statement.

Admitting the above statements to be correct, they prove *only* that these raft and boat-men studied the *surface* currents of the rivers to expedite their business, beyond which they are *uninformed.*

However correct the above statements may be, it does not follow, that there is any difference in the level of these rivers, either at high or low-water. It is well known that the flood and ebb (that is the rising and falling of the tides) take place long before the currents of *some* rivers change. That is to say, that the flood makes several inches perpendicularly before the surface of the river shows flood, and that at first ebb, the river falls several inches before the surface current sets downwards. Under these circumstances accurate observations became necessary, particularly as there is an impression abroad, that there is a difference in the levels of these rivers.

Discontinuing to copy the report I will state—that for several days, I watched the craft in both rivers, from St. Michael's steeple, as from it both rivers could be

viewed simultaneously. John Kane's statement was fully corroborated, the flood and ebb surface currents commencing about an hour sooner in Ashley than in Cooper river. This fact was reported verbally to Gen. Hayne, then Mayor, as soon as it was well ascertained; but he was told that this phenomenon was compatible with a level state of both rivers. The Ashley, comparatively, a short, shallow river, without streams of any consequence discharging into it, might be considered an arm of the ocean, which rose and fell simultaneously, or nearly so, with the harbour; but that the Cooper being a long and deep river, with several considerable tributaries, the Wando, Back, East and West branches, Goose-creek and others, consumed more time to fill and empty, and consequenly, its action would not be simultaneous with the harbour, but would maintain flood and ebb to a later hour; for the ascending and descending planes of a river's surface must be reversed before the surface currents can be changed. This phenomenon may be easily observed at Marsh's wharf, where it will be seen, that the flood has made several inches, that is, the river has risen or swelled upwards several inches by measurement, whilst the surface current in the channel is still ebbing. This explanation proved to be correct by observations that were subsequently made. It was necessary that this question should be settled, because if the rivers were on different levels, a canal or drain, communicating with both across the Neck, would have a current through it in proportion to the difference of levels, which was supposed to be sufficiently great to create a rapid current between the two rivers, that would cleanse the canal or drain and keep it free; as long,

therefore, as this opinion prevailed, there would be doubt as to the proper mode of proceeding. But there is none now, for this question has been settled. The desired result was obtained as follows:

On Hamilton & Co's. wharf at the east end of Tradd street, a mark was made on the ranging or coping timber, from which the measurements to the surface of the water were to be taken. Here, only one point could be found that would answer the purpose.

At Chisolm's mill, at the west end of Tradd-street, four points, all near to each other, so that the four measurements could be made in two or three minutes, were marked, from which the measurements were to be made; several were preferred to one to insure correctness.

The observer at Hamilton & Co's. wharf was called A; the other, at Chisolm's mill, B. They were provided with good watches, set to time, and with whatever else was necessary. The points of observation were upwards of a mile apart. The measurements were made every half hour, and their books taken from them at the end of each day's duty, before they *could confer*. On the next day *new books* were given to them, so that they never knew, until my report was drawn out, whether their observations agreed or not. These precautions were taken to insure true reports.

A and B were instructed how to take the measurements, and practised accordingly on March 1st and 2d, 1837;—the 3d was cloudy with high winds, *unfit*.—Snowed from 10 till 2 on the 4th, *unfit*;—practised again on the 5th and 6th, when they became fully qualified for duty.

What are usually termed the flood and ebb tides are nothing more than the water running down the inclined sides of the lunar wave which enters the harbour from the ocean, where it is formed and travels up the rivers. For when water is heaped up in the form of a wave, the particles are running down from the vertex to the base on each side, and the higher the crest, the deeper will be the trough where there is a succession of waves: for which reason it is, that *spring* tides are lower as well as higher than *neap*, when extraneous circumstances, such as high winds, do not influence them.

In saying that the lunar wave *enters* the harbour, would seem to imply that it rolls in upon us, which is not precisely the fact, for we, (Charleston harbour,) rush through it, which produces the same effect.

The moon passes round the earth in an easterly direction once in about a month; but as the earth revolves on its axis once in every twenty-four hours in the same direction, we overtake her once in a little more than every twenty-four hours; and as the summit or crest of the lunar wave follows the moon, which, by attraction, heaps up the ocean waters, we rush into and pass through two waves in every twenty-four hours, or thereabouts. Supposing that we enter the wave at 6 o'clock A. M., it is then low-water. Six hours after, or at 12 o'clock, we reach the summit or crest, it is then high-water, for we have travelled on the base of the wave. Six hours afterwards, or at 6 o'clock P. M., we arrive at the other edge of the wave, having passed through it, when it is again low-water.

It will afford any one pleasure to read two letters of

Dr. B. Franklin, written at London, the one dated Sept. 13, 1760, the other March 30, 1761. Parts of them are as follow: *(See Diagram, Plate* 2, *Fig.* 1.*)*

Letter, Sept. 13, 1760.—"But I shall now endeavour to explain what I said to you about the tides in rivers, and to that end shall make a figure, which, though not very like a river, may serve to convey my meaning. Suppose a canal one hundred and forty miles long, communicating at one end with the sea, and filled, therefore, with sea-water. I choose a canal at first, rather than a river, to throw out of consideration the effects produced by the streams of fresh water from the land, the inequality in breadth, and the crookedness of courses.

Let A, C, be the head of the canal; C, D, the bottom of it; D, F, the open mouth of it next the sea. Let the straight pricked line, B, G, represent low water mark the whole length of the canal; A, F, high-water mark. Now, if a person standing at E, and observing at the time of high-water there, that the canal is quite full at that place up to the line E, should conclude that the canal is equally full to the same height from end to end, and therefore there was as much more water come into the canal since it was down at low-water mark, as would be included in the oblong space, A, B, G, F, he would be greatly mistaken. For the tide is a *wave,* and the top of the wave, which makes high-water, as well as every lower part, is progressive; and it is high-water successively, but not at the same time, in all the several points between G, F, and A, B. And in such a length as I have mentioned, it is low-water at F, G, and also at A, B, at or near the same time with its being high

water at E; so that the surface of the water in the canal during that situation, is properly represented by the curve pricked line, B, E, G. And, on the other hand, when it is low-water at E, H, it is high water both at F, G, and at A, B, at or near the same time; and the surface would then be described by the inverted curved line, A, H, F. In this view of the case, you will easily see that there must be very little more water in the canal at what we call high-water, than there is at low-water; those terms not relating to the whole canal at the same time, but successively to its parts. And if you suppose the canal six times as long, the case would not vary as to the quantity of water at different times of the tide; there would only be six waves in the canal at the same time, instead of one, and the hollows in the water would be equal to the hills.

That this is not mere theory, but conformable to fact, we know by our long rivers in America. The Delaware, on which Philadelphia stands, is, in this particular similar to the canal I have supposed of one wave; for when it is high-water at the capes or mouth of the river, it is also high-water at Philadelphia, which stands about one hundred and forty miles from the sea; and there is at the same time a low-water in the middle, between the two high-waters; where, when it comes to be high-water, it is at the same time low-water at the capes and at Philadelphia. And the longer rivers have some a wave and a half, some two, three, or four waves, according to their length. In the shorter rivers of this Island, one may see the same thing, in part; for instance, it is high-water at Gravesend one hour before it is high-water at London Bridge; and twenty miles

below Gravesend one hour before it is high-water at Gravesend. Therefore, at the time of high-water at Gravesend, the top of the wave is there, and the water is then not so high by some feet where the top of the wave was an hour before, or where it will be an hour after, as it is just then at Gravetend.

Now we are not to suppose that because the swell, or top of the wave runs at the rate of twenty miles an hour, that therefore the current, or water itself, of which the wave is composed, runs at that rate. Far from it. To conceive this motion of a wave, make a small experiment or two. Fasten one end of a cord in a window near the top of a house, and let the other end come down to the ground; take this end in your hand, and you may, by a sudden motion, occasion a wave in the cord that will run quite up to the window; but, though the wave is progressive, from your hand to the window, the parts of the rope do not proceed with the wave, but remain where they were, except only that kind of motion that produces the wave. So if you throw a stone into a pond of water when the surface is still and smooth, you will see a circular wave proceed from the stone at its centre, quite to the sides of the pond; but the water does not proceed with the wave, it only rises and falls to form it in the different parts of its course; and the waves that follow the first, all make use of the same water with their predecessors. But a wave in water is not indeed in all circumstances exactly like that in a cord; for water being a fluid, and gravitating to the earth, it naturally runs from a higher place to a lower; therefore the parts of a wave in water do actually run a little both ways from its top towards its

lower sides, which the parts of the wave in the cord cannot do. Thus, when it is high and standing water at Gravesend, the water twenty miles below has been running ebb, or towards the sea for an hour, or ever since it was high-water there; but the water at London Bridge will run flood, or from the sea, yet another hour, till it is high-water, or the top of the wave arrives at that Bridge, and then it will have run ebb an hour at Gravesend, &c.

Now, this motion of the water, occasioned only by its gravity, or tendency to run from a higher place to a lower, is by no means so swift as the motion of the wave. It scarce exceeds perhaps two miles in an hour. If it went as the wave does, twenty miles an hour, no ships could ride at anchor in such a stream, nor boats row against it.

In common speech, indeed, this current of water both ways from the top of the wave is called *the Tide;* thus, we say, *the Tide runs strong; the Tide runs at the rate of one, two, or three miles an hour, &c.*—and when we are at a part of the river behind the top of the wave, and find the water lower than high-water mark, and running towards the sea, we say, *the Tide runs ebb;* and when we are before the top of the wave, and find the water higher than low-water mark, and running from the sea, we say, *the Tide runs flood;* but these expressions are only locally proper; for a tide, strictly speaking, is *one whole wave,* including all its parts higher and lower, and these waves succeed one another about twice in twenty-four hours.

This motion of the water, occasioned by its gravity, will explain to you why the water near the mouths of

rivers may be salter at high-water than at low. Some of the salt-water, as the tide wave enters the river, runs from its top and fore side, and mixes with the fresh, and also pushes it back up the river.

Supposing that the water commonly runs during the flood at the rate of two miles in an hour, and that the flood runs five hours; you see that it can bring at most into our canal only a quantity of water equal to the space included in the breadth of the canal, ten miles of its length, and the depth between low and high-water mark; which is but a fourteenth part of what would be necessary to fill all the space between low and high-water mark, for one hundred and forty miles, the whole length of the canal. And indeed, such a quantity of water as would fill that whole space, to run in and out every tide, must create so outrageous a current as would do infinite damage to the shores, shipping, &c., and make the navigation of a river almost impracticable.

I have made this letter longer than I intended, and therefore reserve for another what I have further to say on the subject of tides and rivers. I shall now only add, that I have not been exact in the numbers, because I would avoid perplexing you with minute calculations; my design at present being chiefly to give you distinct and clear ideas of the first principles.

Letter. March 30, 1761.—You are, I think, quite right in your opinion, that the rising of the tides in rivers is not owing to the immediate influence of the moon on the rivers. It is rather a subsequent effect of the influence of the moon on the sea, and does not make its appearance in some rivers till the moon has long passed by. I have not expressed myself clearly,

if you have understood me to mean otherwise. You know I have mentioned it as a fact, that there are in some rivers several tides, all existing at the same time; that is, two, three, or more high-waters, and as many low-waters, in different parts of the same river, which cannot possibly be all effects of the moon's immediate action on that river; but they may be subsequent effects of her actions on the sea."

Ferguson's Astronomy, p. 155.—"In open seas, the tides rise to very small heights in proportion to what they do in wide-mouthed rivers, opening in the direction of the stream of the tide. For in channels growing narrower gradually, the water is accumulated by the opposition of the contracting banks. Like a gentle wind, little felt on an open plane, but strong and brisk in a street; especially if the wider end of the street be next the plane, and in the way of the wind."

Rennell's Memoir, p. 354,—M. De Condamine says: "The tides in the river Amazon are perceptible at 600 miles above its mouth, at an elevation of ninety (90) feet above the level of the ocean."

Resuming the Subject.—March 6th, 1837, was a fine day, with a pleasant breeze from the South-East. It being new moon on the afternoon of this day, and as high-tides were to be expected on the 7th and 8th, it was thought advisable to proceed with the examination of the tides on these days. Accordingly, A. and B. were on duty at their posts on the 7th, from 8½ A. M., till 5 P. M., and reported the state of the tide at each point every half-hour. They did so again on the 8th, during the same period.

Here again I copy from the report of the 24th March, 1837, on file in Council Chamber.

On comparing the respective Reports of Assistants A and B, the following results are obtained.

Average rise and fall as per A's Report 7th March.		Average rise and fall as per B's Report 7th March.		Average rise and fall as per A's Report 8th March.		Average rise and fall as per B's. Report 8th March.	
H. min.	Ft. in.	H. min.	Ft. in.	H. min.	Ft. in.	H. min.	Ft. in.
8 30 *high w.*	6 3	8 30 *high w.*	1 2	9 0 *high w.*	6 2	9 0 *high w.*	1 0
9 *fall*	4½ in.	9 *fall*	2½ in.	9 30 *fall*	1½ in.	9 30 *fall*	2 in.
9 30 "	7 "	9 30 "	6½ "	10 "	6 "	10 "	5½ "
10 "	8 "	10 "	8 "	10 30 "	8½ "	10 30 "	7½ "
10 30 "	9 "	10 30 "	9 "	11 "	9½ "	11 "	9½ "
11 "	9 "	11 "	10 "	11 30 "	9 "	11 30 "	9½ "
11 30 "	10 "	11 30 "	10½ "	12 "	9¼ "	12 "	9½ "
12 "	11 "	12 "	11 "	12 30 "	10¼ "	12 30 "	10 "
12 30 "	12 "	12 30 "	10½ "	1 "	10 "	1 "	9½ "
1 "	7¼ "	1 "	9 "	1 30 "	9½ "	1 30 "	9 "
1 30 "	6¼ "	1 30 "	7 "	2 "	7 "	2 "	8 "
2 " *low-water*	3¼ "	2 " *low-water*	3½ "	2 30 "	5 "	2 30 "	5 "
				3 " *low-water*	1 "	3 " *low-water*	3 "
2 30 *rose*	0¼ "	2 30 *rose*	0½ "	3 30 *rose*	1¾ "	3 30 *rose*	2 "
3 "	4½ "	3 "	3½ "	4 "	7¼ "	4 "	5 "
3 30 "	6¼ "	3 30 "	6½ "	4 30 "	10 "	4 30 "	8½ "
4 "	10 "	4 "	9 "	5 "	9 "	5 "	11 "
4 30 "	10¾ "	4 30 "	11 "				
5 "	11¼ "	5 "	11½ "				
	130¼ in.		129½ in.		114½ in.		114½ in.
Hamilton & Co's. wharf.	Ft. in.	*Chisolm's Mill.*	Ft. in.	*Hamilton & Co's wharf.*	Ft. in.	*Chisolm's Mill.*	Ft. in.
Low-water at 2 P. M.	13 6½	at 2 P. M.	8 5½	Low-water at 3 P. M.	13 4½	at 3 P. M.	8 4
High-water at 8½ A. M.	6 3	at 8½ A. M.	1 2	High-water at 9 A. M.	6 2	at 9 A. M.	1
Difference,	7 3½	Difference,	7 3½	Difference,	7 2½	Difference,	7 4

From the reports of assistants A. and B., it appears, that it is high and low-water at the same time in both rivers at the east and west ends of Tradd-street, and that the tides are of equal height, and that they rise and fall equally, preserving the same level. It follows, therefore, that all plans predicated on a difference of the levels of these rivers, will fail, being contrary to facts; and that the cleansing of the drains must be effected by artificial construction and management.

So far for my report of the 24th March, 1837. But being desirous of ascertaining what time for clean drainage the level of the Calhoun-street drain allows, I proceeded on the 1st October, 1853, to investigate it.

The level of the bottom of this drain at its vent, was transferred to the head of Marsh's wharf, and measurements made to ascertain the state of the tide, which was ebbing.

At 11¼ A. M., the tide had fallen to the level of the bottom of the drain. At 12½ P. M., it was low-water. And at 1¾ P. M., the tide had risen to the same level again, being a period of 2½ hours. But owing to prevailing winds from the N. E., the tide on this day did not fall as low as it frequently does by six or nine inches.

Again—It having been new moon on the 2d, these operations were repeated on the 4th October, 1853, with the same result. The wind was very high from N. E., which, with the age of the moon, produced a very great spring-tide, seldom exceeded, independent of storms, which also had the effect of preventing the harbour waters from falling as low as customary at such periods. The same time, however, of 2½ hours, for

clean drainage, was obtained. It follows, that we may safely rely on 2½ hours as the least period for clean drainage, and, when westerly winds prevail, on three hours.

I come, then, to the conclusion, that the vent of the Calhoun-street drain is at the proper level, and ought not to be materially deviated from. The tides will prevent a *lower* grade, and the scant elevation of the Neck a *higher*. This level, therefore, is well adapted to the Tidal System.

HEIGHT OF SEWERS.

Before determining on this dimension, it is proper to consult the opinions of others. In Mr. Dempsey's Treatise, page 94, the article 280 reads as follows: "The *capacity* of sewers is determined by a consideration jointly of the *quantity* of sewage to be conveyed through them, and of the rate of inclination or fall in the vertical position. The capacity will vary directly as the quantity, and inversely as the fall; since the greater the fall, the more rapid will be the discharge. It has been usual to prescribe another limitation as to the minimum capacity of sewers, viz: that they shall at least, under all circumstances, be large enough for a man to pass along them. The necessity for this allowance has arisen from the fact, that sewers are found to require cleaning by hand; that it is utterly impossible to remove the accumulations which are liable to occur within them by any other means, and thus, £10,000 has been annually expended in London alone in an employment of the most disgusting and dangerous nature. We have no hesitation in saying,

that under a thoroughly efficient and practicable system, no such process could ever be needed, and, moreover, that if deemed desirable for any purpose, it would apply only to the principal sewers, the size of which would admit of it, as determined upon the joint data of *quantity* and *fall alone.* We will, therefore, dismiss this condition from the problem, and study it upon the two data named."

This paragraph is, generally, assented to, on the condition, that the drains proposed to be constructed according to Mr. Dempsey's plan would keep themselves free and clean; which is the result expected from the system about to be proposed for Charleston; although the systems are totally different, the former being that of inclined planes, best adapted to London, whilst the latter is the tidal, best adapted to Charleston. But it is argued, that even admitting that the common sewers will cleanse themselves, it still becomes necessary to construct them of sufficient height to enable workmen to repair them from within, and to make openings for the junction of yard-drains, which should be carefully done with cement. But supposing, that, contrary to expectation, these common public sewers do not cleanse themselves; what then? Take them up and build new ones? or be subjected to the inconvenience and expense of ripping up the pavements, &c., to clean them by hand? This will not do. Sufficient height should be given to the common public sewers, to answer every contingency. A few courses of brick-wall on each side, to obtain a convenient and desirable height, would add but little to the expense of construction, as every other item, including the ex-

cavation, would remain the same; and in floods of rain, particularly at high-water, it might be needed, unless additional precautions be taken. In conformation of these views, Mr. Dempsey's treatise is quoted, page 150, articles 346 and 347.

Article 346,—"By another of the regulations of the Commissioners of the city sewers, affecting the details of the house drains, we find, that since the year 1832, the Commissioners have required that their own tradesmen should be employed to make the whole of the drains up to the front of the buildings, these drains being 15 inches in diameter. And the reason alleged for this regulation was, that the Commissioners found great difficulty in getting individuals to make the drains substantially."

Article 347,—"The regulations laid down by the Commissioners of sewers for Westminster for the construction of private drains were as follow: That no drains shall be laid into a public sewer without a special leave for that purpose from the Commissioners. That when such leave shall be obtained, the opening into the sewer shall be made, and the drain built, for a length of three feet from the sewer, according to a plan and section approved by the Commissioners, and paid by the party requiring the drain, at the prices undermentioned. For cutting through the springing wall of the sewer, putting in a cemented brick ring, and soundly underpinning the wall round the same, the sum of 10 shillings and 6 pence for each opening, &c."

Let it be observed that work of this description can be better done by having access to the interior of the sewer than without, and when flushing becomes neces-

sary, the interior of the sewer should be even and regular, without any protuberances whatever. Besides which, in executing work of this description, brick-bats are frequently knocked through into the sewer, which should not be permitted to remain there.

Penny Cyclopedia, vol. 21, p. 314,—" Mr. Walker, the engineer, in evidence before a Parliamentary committee, in 1834, stated, that when, in the previous year, some French engineers were sent over to England by their government, nothing seemed to attract their attention more than the sewerage of London, the drainage of Paris being a subject then under consideration ; but he adds, their ideas of the proposed drainage never extended to more than taking away the surface drainage, and they seemed astonished when I told them that the water from our lowest cellars, drains into those great sewers." Page 316,—" As sewers are from their peculiar situation and use, more difficult to examine and repair than other structures of brickwork, while a defect may be productive of very serious injury before it attracts notice, it is especially desirable that they should be constructed in the most perfect and durable manner ; * * * * &c. All the sewers constructed of late years, are of such dimensions as to *allow a man to pass through them*, for the purpose of inspecting or cleansing them. In the district under the management of the Westminster Commissioners, the common sewers are built of the form represented by the annexed transverse section, (*Plate* 2, *Fig.* 2) which represents a sewer of the largest sort, the greatest height being 5 ft. 6 in., and width 3 ft."

This is the size that I should have recommended for the common sewers to pass through all the streets, with the exception of the main or feeding sewers, which must be 6 inches deeper than the common; and as the scant elevation of the Neck will not allow of 7 feet in the clear for the main sewers, we must be contented to make the *common* sewers only 5 feet high, reserving 6 inches more for the *main* sewers that should extend *from river to river*. Let it be remembered, that the first sewers constructed in East Bay-street, are not less than 4½ feet high in the clear, so that 5 feet is only an addition of 6 inches. Though 5 feet 3 inches is said to be one of the largest size sewers in the *Westminster* division, yet, in other districts of London, they far exceed these in size; which will be treated of hereafter. But, although the *main sewers* will require much greater *width*, the height of 5½ feet will answer every purpose. I am of opinion that the *common sewers* should be 5 feet high in the clear, and the *main sewers* 5½ feet. Having determined on the height, we come next to the consideration of the width.

WIDTH OF SEWERS.

For the *common* public sewers 3 feet is desirable; but, as feeders, the *main* sewers will require 7 feet.

Dempsey, p. 93,—" By way of conveying a ready idea of the vast size of the Fleet sewer, the great length and extended functions of which have been before noticed, the two figures, (*Plate* 2, *Figs.* 3 & 4) are introduced, the one showing the section of the sewer at the city boundary, where its dimensions are 12 ft. 3 in.

by 11 ft. 7½ in., and the other showing the size of the mouth of the sewer, which is 18 ft. 6 in. by 12 feet, and of ample capacity to admit *one of the largest locomotive engines*, the gigantic dimensions of which are sufficiently familiar to all who have found it necessary to cross the platform of a railway station. Yet this sewer "has been surcharged; and only within the last year, (1842,) the culvert, so ably constructed at its mouth, by Mr. James Walker, was severely injured by the flood consequent upon a thunder-storm." (Evidence of the Surveyor to the City Commission of sewers, before the "Commissioners of Inquiry into the state of large towns and populous districts, 1843.")

FORM OF SEWERS.

The London sewers are various in form. 1. Flat bottom, upright walls, and arched top. 2. Invert bottom, upright walls, and arched top. 3. The egg-shape of various figures and proportions.

The flat bottom with upright walls have generally been superseded by the invert bottom with upright walls, and these again, in some measure, by the egg-shaped.

The flat bottom is of the simplest construction, and most economical, but requires more water to keep it clean and free than the invert, which is stronger by construction and requires less water for cleaning, but is more costly. The egg-shape is the most difficult to construct, and the most costly, but requires the least water to keep it free. The best proportioned egg-form is that of Mr. Dempsey, who describes it as follows, on pages 105 and 106:—

"In the forming of sewers as in all works of a similar class, which are often necessarily entrusted, to a great extent, to the charge of workmen, who cannot be expected to pay much attention to the refinements of geometrical principles, *simplicity* is evidently an object of the first importance. The proportions of the several curves required in making out the section, and forming the moulds and gauges to be used in constructing and testing the work, should be such as can be readily understood and exactly remembered: and, in proportion as these rules are observed in designing the form, will be the probability of that form being preserved and exactness attained in the construction of the sewer. In seeking this object, we have worked out a diagram of proportions, (shown in *Plate* 2, *Fig.* 7,) that we can venture to recommend on the score of simplicity and sufficiency, which we hope will be evident by the figure and the following description. In this section, let the diameter A, A, of the upper semicircle, A, D, A, equal 1; that of the lower arc, B, B, will equal 5. The entire height of the section D, F, will equal 1.5, and the radius C, A, A, of the side arcs (truly tangential to the upper and lower arcs,) will also equal 1.5. The centres, C, C, being upon the produced diameter of the upper arc, that arc will equal a semicircle, and the lower arc, B, B, will equal 120 degrees, the points for the meeting of the curves being at B, B, found by drawing the radial lines, C, B, through the centre E, of the lower arc. Suppose the greatest diameter, A, A, be determined at 3 ft., the several dimensions will be thus:

	ft.	in.
Diameter of upper arc - - - - - - - -	3	0
Do " lower " - - - - - - - -	1	6
Height of section - - - - - - - - - -	4	6
Radius of tide arcs - - - - - - - - -	4	6

And the area may be taken (as a very close approximation to the truth) as equal to that of a semicircle of 3 feet diameter, added to the area of a circular segment whose radius is 4 ft. 6 in., and versed *sine* 1 ft. 6 in.; the area thus given being in excess only the small space shown in shaded lines at G."

When the minimum of water is the *first* consideration, this form is preferable to any other. But for a tidal system, based upon drawing on the ocean for water, where the supply is inexhaustible, other considerations prevail, for this particular form is no longer necessary. The invert bottom, (*Plate* 2, *Figs.* 2, 3, & 4,) is for the Tidal System preferable, being of easier construction, and after completion, much more convenient for inspectors and workmen. In fact, was it not that the flat bottom may not bear *flushing*, I should prefer it to the invert, for its simplicity of construction and economy; but there can be no question of the greater strength and permanence of the invert, which is, therefore, preferable.

Extracts from Dempsey: Art. 271,—" The proportions, dimensions, inclinations, forms and construction of main and all other sewers, are all more or less affected and determinable by the general system of drainage adopted. We will first cull from the mass of recorded experience at our command, (up to the year 1843) some detailed particulars of modes of construc-

tion, many of which have been found *inefficient* in fulfilling the *self-discharge* of the sewage matters of London and other towns in England."

Art. 272,—" The experience in the City of London led the Surveyor to the Commissioners of sewers to consider that the form of a semicircular top and bottom, with straight (or vertical) sides, " answered all the conditions of a sewer." Nevertheless, many have been constructed of an oval form. The smallest size, in a long street, is 4 ft. 6 in. by 2 ft. 6 in. The other sizes are 5 ft. by 3 ft.; but several are considerably larger, where much water is expected to accrue from the outer districts. The outlet for the main sewer at South Place, (Finsbury,) is 6 ft. 6 in. by 4 ft. 6 in. The Fleet sewer, which *drains from the south-west of Highgate, is* 18 *ft.* 6 *in. by* 12 *ft. at the mouth, and* 12 *ft.* 3 *in. by* 11 *ft.* 7½ *in. at the city boundary ; and, owing to the immense quantity of water flowing into it. " this sewer has often been surcharged."* The Eldon-street (Finsbury) sewer is 6 ft. by 3 ft. 2 in.; the London Wall sewer is 6 ft. by 4 ft., and the main trunk increases from 8 ft. 3 in. by 6 ft. 9 in., to 10 ft. by 8 ft. at its mouth."

Art. 273,—" In the Westminster division of sewers the level of the outfalls into the river varies from 10 to 15 ft. below the level of high-water mark, and some of them have flaps. Some of the main sewers have a *fall of only half an inch to* 100 *ft.* The form of the sewers is that of a semicircular arch at the top, and a segmental invert with upright sides. The two sizes used are—first class, 5 ft. 6 in. high and 3 ft. wide; and, second class, 5 ft. high and 2 ft. 6 in wide. The three

centre courses of every invert are built in cement, and the remainder of the work in Dorking lime-mortar."

Art. 274,—" The sewers throughout the Holborn and Finsbury divisions discharge into the main sewers of the City of London, and have no outfalls of their own into the Thames. A sewer carried up to Holloway, in this division, a length of nearly 3 miles, passes under Canonbury (Islington) at a *depth of* 68 *ft. from the surface*, and the drainage of the houses in that part is provided for by a *subsidiary sewer*."

Art. 275,—" Sewers constructed on the Kingston estate, through a very soft clay, are built of an oval form, the largest size being 3 ft. 6 in. high, and 2 ft. 6 in. wide, the radius of the side curves about 3 ft., half a brick thick in cement. The extent of cutting was from 16 to 18 feet. The fall at the rate of 80 feet in a quarter of a mile."

It is evident from all that has been said, that the invert with upright walls and arched top, the *common* 5 feet by 3, and the *main* 5½ by 7, are best adapted to our Tidal system; for the form and size depend on location and system.—(*Plate* 2, *Fig.* 5 the common, and *Fig.* 6 the main sewer.)

CONSTRUCTION OF SEWERS.

In a Tidal system it is evident that where the river is salt, that mortar made of lime and gravel is objectionable; because mortar so made when fresh is "killed" by the salt water, and never hardens. Hydraulic cement of some kind that "sets" immediately, forming a solid body with brick and stone, must be used.

Here, in Charleston, we know that walls one brick

(9 inches) thick, laid in good mortar, are sufficiently strong for the common sewers, when they are out of the reach of the salt tides, and consequently that walls of 9 inches built with cement, will answer for the tidal *common* sewers. The walls of the *main* sewers should be 14 inches thick, laid with cement. With regard to the arches, they should be two half bricks, (9 inches) thick, the inner brick should be laid in cement, the outer may be laid in mortar. The invert should be built with bricks moulded for the purpose, and both bricks should be laid in cement. All superstructures require but good mortar. Good *shell*, not stone lime, should be used with fresh water gravel. The sewers will rest on two inch planks laid across each other as will be described hereafter.

CUTTING OR DEPTH OF SEWERS.

We have seen from quotations already made, that the London sewers are from 16 to 68 feet under ground; whilst the greatest depth of ours will not exceed ten feet to the crown, and the *average* cutting not more than from 10 to 11, as appears by the diagram. We have nothing to complain of on this score, deeper cutting would be desirable to afford sufficient depth for the subsoil drainage of the squares.

PILING.

It is believed that piling will be unnecessary, for where marsh ravines formerly existed, it is supposed that ample support for the sewers will be obtained by extending the planks laterally a few feet beyond the walls of the sewers.

PLANKING.

The planks should be two inches thick. Two of them, one under each wall running in its direction should first be laid, then others crossing them, forming a *continuous* floor, on which the foundation and invert will be built. These planks to extend in every place at least six inches beyond the walls, and where the soil is not sufficiently firm to sustain the weight of the sewer, as much further as may be necessary.

THE SYSTEM.

Having shown that the level adopted is such as to ensure about three hours clean drainage at low-water, and having established the form, size, and construction of the sewers, it now remains to be shown, how a tidal, which necessarily infers a level system, can prove efficient. How sewers built on a level can cleanse themselves, and prove as efficient as those constructed on inclined planes. Neither London nor Paris is as advantageously located as Charleston for a system of drainage. Theirs, in part, must be that of *inclined planes;* ours, of necessity, must be *Tidal.*

Dempsey, Art. 205,—" The large sewers constructed in the Tower Hamlets Division are 4 ft. 6 in. by 3 ft. One of the sewers, from Hoxton New Town, is laid, for a length of 3,000 *feet, on a dead level,* and discharges into another, which is also on *nearly a dead level,* because a fall could not be obtained."

This is one of the defects incident to a system of *inclined planes,* for at some places the land rises so suddenly that either a fall greater than is desirable must be given, or the sewer buried to a very inconvenient and

costly depth; whilst at other points they are unavoidably constructed on *dead levels for a great distance.* There are no such impediments on Charleston Neck with a *Tidal* System.

Dempsey, Art. 208,—"In the Westminister division the outfalls to the river vary from 10 to 15 feet below the level of high-water mark, that is about 5 feet above low-water mark, and some of them are provided with flaps. The cost for cleansing sewers by hand, made necessary by deficient fall, amounted in the year 1852, to £1850; the average for seven years, being about £1550, and this deposit is so hard that it is sometimes found necessary to use the pick-axe to dislodge it. The size of the main sewers is 5 ft. 6 in. in height, and 3 feet in width, and of this size 32,000 yards were constructed from 1833 to 1843. In 1843, one of the sewers in this division, the King's Scholar's Pond Sewer, was described to have from its commencement at Shepherd's Well to the flood-gate at the Thames, a total fall of 285 ft. 4 in., yet the fall is in some points very deficient. In the Pimlico district adjoining the palace, the fall is for the last 5500 feet only 5 ft.,—less than a foot in each thousand feet, and the outlet was still so low that flood-gates were necessary at the outlet. During the rising of the tides, therefore, these gates were closed for six hours, and the sewage of course remained pent up or thrown back towards the houses."

Art. 209,—"In the Kent and Surry divisions, in which there are several open sewers, the drainage is so conducted, that, "during the time the tide is up in the river, the sewers have to receive all the water making its way into them, and must be sufficiently capacious to

hold both that quantity, and all rain that may fall, until the fall of the tide allows a discharge." The covered main sewers are 5 ft. 3 in. by 4 ft. 9 in. The whole of this district is many feet under high-water mark."

There are no such difficulties to be encountered on Charleston Neck. We will now show that *level* drains can be *flushed* as well as those that are built on *inclined planes* having descent or falls.

FLUSHING OF SEWERS.

Dempsey, Art. 308,—" The method of cleansing the sewers in which matter accumulates, by flushing water through them, was practised to a great extent in the Holborn and Finsbury division of sewers, and has been adopted by the New Metropolitan Commission of Sewers. The principle of this method consists simply in retaining the sewage water for a period of time by flushing gates fitted in the sewer, and periodically admitting the accumulated water to pass by opening the gates, and thus producing an artificial rush sufficient to carry all accumulations before it. The relative economy of the process, as practised in the Holborn and Finsbury division, and, as compared with the hand cleaning, was stated as follows, * * * * * * &c. The cost of this method, as subsequently practised under the New Metropolitan Commission of Sewers, has been reported as being about one-third that of cleansing by hand; thus 22,400 ft. of sewers, (in which the deposit varied from 6 in. to 3 ft. 6 in.) were cleansed, and 3386 double loads washed away at an expense of £500; which process under the old system, would have cost £1500."

Penny Cyclopædia, p. 318,—"The last mentioned improvement (curves of drains) is intimately connected with another, which promises to be of great value,—a method of cleansing sewers by using water in *flushes.* A great quantity of solid matter enters the sewers with the waters which they are intended to carry off; and as their current is usually very trifling, it is deposited in the form of a sediment. This takes place especially at the points of junction of branch sewers, gullies, and private drains; and it has often happened, that the deposit has gone on accumulating until it has reached the level of the private drains, the consequent choking up of which has given the first intimation of the state of the main sewer. Although in general the current of water in the sewers is not sufficiently rapid to carry off this solid matter, Mr. Roe, conceiving that it might be made so by damming it up, and then letting it off in flushes, tried a series of experiments on the velocity of water in sewers when dammed up to various heights, by which he found that he could, by a head of water varying from 10 *inches* to 4 feet, obtain a velocity of from *thirty to eighty-six inches per second.* The power of running water at various velocities has been treated of in the article Alluvium, (vol. 1, p. 357,) where it is stated that a velocity of 3 inches per second is sufficient to enable a current of water to tear up fine clay; and that a stream running at the rate of 3 feet per second will tear up beds of loose stones of the size of an egg. It is therefore evident that by a moderate head of water in a sewer, a current may be produced of sufficient force to tear up and carry away a considerable deposit of sedimentary matter. To show the effect of the ope-

ration in practice, we quote the particulars of these experiments, from a report presented by Mr. Roe to the Commissioners.

1*st Experiment.*—Water backed up 70 feet; head 13 inches; quantity, 26 hogsheads; which, when let off, cleared away rather more than 1½ inch of deposit from 370 feet of sewer, having a fall of a quarter of an inch in each 10 feet, and being the whole length that needed cleaning.

2*d Experiment.*—Head of water 18½ inches; quantity, 45 hogsheads, cleared away 1½ inch of deposit from 300 feet of sewer, *part of the bottom* on a *dead level.*

3*d Experiment.*—Head of water 10 inches; quantity, 20 hogsheads; deposit heavy; flush cleared away 1¼ inch from 330 feet of sewer."

In the 2d experiment it is stated, that a part of the sewer was on a *dead level.* It is not, in the least surprising, that the scouring operation continued over the *dead level;* for as the head of water was sufficient to *rush* over the dead level, the scouring would be more complete; for resisted by the firm bottom of the sewer its stirring effect on the sediment would be greater.

If a stream of water rushes over a precipice it will not fall perpendicularly, but be projected on an angle in proportion to its velocity. Suppose a stream of water one foot deep and three feet wide rushing over a precipice. Place a board at the edge of the precipice extending perpendicularly to the base or ground; the water will not run on the board but jet over it. Raise the bottom of the board from the ground, as though the top was hinged to the precipice, until it meets or

touches the under part of the jetting stream; there will, in this position, be little or no weight on the board; but raise the board a few degrees more towards a horizontal position, and the weight of the stream will sensibly increase until the board attains the horizontal or level position, when the whole weight of the stream will be felt and supported by the board. Consequently a rushing stream passing over a level surface presses harder upon it than when passing over a descending plane, and therefore the scouring effect will be greater; for the tendency of the water will be proportionately exerted to make a channel for itself to descend through. This problem has its limits, for the stream must be sufficiently rapid to stir and raise the particles of sediment, or if there be sand too heavy to be raised and swept along, to cause it to travel by rolling, a phenomenon very common on the beach of sea islands, where little ridges of sand are seen after the sea has receded. These little ridges of sand are known to travel, each succeeding the other, like waves in water, at the rate of 20 feet per day, and by this operation, gravel, too large and heavy to be floated down by the current, descend rivers from the mountainous interior of a country to the sea-board. The *Abbe Bossut* found, that when the velocity of the stream was just sufficient for lifting the sand (and a small excess hindered this operation altogether) a ridge advanced 20 feet in a day.

Now, as it was proved by the 2d experiment, that a head of 10 *inches* of water was sufficient to scour out a sewer on a *dead level*, 5 *feet* cannot fail to produce a much more powerful effect.

From these experiments it cannot reasonably be

doubted, that with an unlimited head of water 5 feet deep a thorough cleansing can be effected by this system. Two or three feet flushing would probably suffice, for it would be unnecessary and perhaps unsafe to flush with all the power at this system's command, for the sewers may be injured by the violence of the currents that may be forced through them. Flushing will be practised periodically, monthly or quarterly, as may be requisite; ordinarily the tides will flow and ebb through them, or they may be excluded altogether, excepting at periods of flushing.

HEAD OF WATER.

The Tidal System, with main and common sewers constructed as proposed, will afford a head of water greatly exceeding what can be needed, and is therefore termed *unlimited.* On reference to the diagram, (*Plate* 2, *Fig.* 9,) it will be observed the great extent of sewers that can be made subservient to the flushing of any one of them, or any part of each. For as they *all* are on the *same level,* they will contain about 4 feet of water at common tides, and will be entirely filled at spring tides, which occur every fortnight, at new and full moon. To effect such action, a very simple contrivance only is necessary, which will be explained.

COMBINATION OF SEWERS.

To explain this matter let us refer to the diagram, (*Plate* 2, *Fig.* 9,) which embraces but a small division, bounded North by John and Chapel-streets, South by Calhoun-street, East by Washington-street, and West by Meeting-street.

Let a main sewer 5½ feet high by 7 wide be constructed from A to B, and through all the other streets, common sewers 5 feet high by 3 wide. At high-water close the common sewers at C, D, E, and F, by slides, which are more convenient and simple of construction than gates. When the main sewer A, B, becomes empty, by the falling of the tide, all the common sewers will remain filled with water. If then it be proposed to scour out the common sewer B, G, in Meeting-street, raise the slide F, and the contents of the whole head of water contained in all the other common sewers must pass through the common sewer G, F, at a rate or velocity of at least 5 miles an hour, the efficiency of which no one can doubt.

Again.—Let it be proposed to scour out the common sewer E, H, in Elizabeth-street; then as before, when the main sewer becomes empty, all the slides being down, raise the slide E, when the whole head of water must pass through H, E, and cleanse it out. In like manner each and every sewer, or a part of any sewer, may be cleaned by the head of water contained in all the other common sewers. Remember this is but a *small part* of a District which could be made to act upon a single sewer. And notice again, that if one scouring does not completely cleanse the sewer, as many more may be given as may be necessary. For as the tide flows and ebbs twice in every 24 hours, so twice in every 24 hours may the operation be repeated without any expense whatever. Attendance on the slides, like a trunk-minder in the rice-fields, is all that would be required.

It will be observed, that the connection of the sewers

must be effected by curves of the greatest radius that the streets will admit, and not by angles, which greatly impede the rush of waters. The junction of sewers must be trumpet mouthed. *(Plate* 2, *Fig.* 8.*)*

IMPERMEABLE AND PERMEABLE.

The public sewers should be *impermeable*, the yard drains *permeable*. The latter are intended to convey the surface waters and slops to the public sewers, and also for the sub-soil drainage of the squares, but should have no connection with privy vaults, the very idea of which is utterly repudiated. The public sewers should simply discharge into the rivers surface waters and the contents of yard drains, which should be conveyed to them in as cleanly a state as the necessities of a dense population will admit. As the public sewers will be *impermeable*, the salt water admitted into them for scouring and cleansing, cannot permeate the soil and affect wells of fresh water.

DIAGONAL DRAINS, SCENT TRAPS, AND SAND PITS.

Diagonal drains for the purpose of venting the surface gutters of the streets, may be made of the simplest construction, the most economical and convenient will be best, but they should be well built, and their junction with the sewers evenly finished off with cement in the interior of the sewer. In other respects good mortar will answer. As the public sewers will be kept sweet by the salt water, they will not emit noxious gases and vapours; consequently *public* scent traps will be *unnecessary*, but scent traps are recommended for *private* yard drains. As to *sand pits*, which are never well

attended, and expensive where they exist, they are alike useless and uprofitable; for whatever enters the sewers will be forced out of them by the rushing waters.

FUNNELS OR SHAFTS, &c.

In the construction of every sewer *funnels* or *shafts* should be built as they progress; if so the cost will be trifling, otherwise they will prove expensive. They are holes in the arches of the sewers, and if not well built, will impair the strength of the arches, particularly those of the main sewers. There must be one wherever a *slide* is to be inserted, but there should be many more at proper distances from each other for the purposes of *inspection*, *repairs*, *branching of yard drains*, *&c.* They should be covered with trap-doors of some description, and of convenient construction for admission into the sewers. Especially it is of the greatest importance that when in the construction of a sewer the work reaches the intersection of a street, that the curved junction be built several feet towards that street, thereby avoiding the necessity of breaking through the sewer subsequently to unite a branch sewer, which should be done in the most workmanlike manner. A similar precaution is recommended for all diagonal and yard drains, which should enter the sewer at the highest point practicable, by which considerable time and expense will be saved, besides having a more perfect structure. The *interior* of sewers should be *smooth.*

London Board of Health, p. 37,—"It appears to be a common doctrine which governed the construction of such works, that it mattered little whether the surface of sewers or drains was smooth or rough; that even if

they were made of rubble stone the only practical effect would be to diminish the diameter of the drains to the space between the points of the protuberances. Upon investigation this doctrine was found to be wholly erroneous, in respect to sewers as well as to house-drains; Mr. Roe showed that brick sewers, whenever the surface was made comparatively smooth with cement, were kept clear of deposit, whilst the sewers having rough brick surfaces, with the same inclinations and the same quantities of sewage, accumulated it."

With regard to *curves*, Mr. Roe ascertained as follows: *Penny Cyclopædia, vol.* 21, *p.* 317,—"It is highly desirable, when a sewer must deviate from a straight line of direction, to effect such deviation by means of regular curves; and also to make branch sewers enter the main line by a curved instead of an angular junction. Mr. Roe ascertained by experiments, that the time occupied in the passage of an equal quantity of water along similar lengths of sewer with equal falls, was as follows:

Along a straight line, - - - - -	90 seconds.
With a true curve, - - - - - - -	100 "
With a turn at right angles, - - -	140 "

That the curves should be formed with a radius of not less than 20 feet."

FLOOD-GATES AND SLIDES.

The mouths or vents of the *main* sewers, so much larger than the *common*, may require gates of a different construction from the slides intended for the common. Of their plan and construction, as well as those of other minor matters we will not here treat, to avoid prolixity.

LOWER WARDS.

I am under the impression that the drainage of these Wards may be greatly improved, as soon as a Main Sewer is constructed in Calhoun-street as far as King-street.

HEALTH OF CITIES.

We treat on this subject only as connected with sewerage, drainage, water, and privies. As usual, we shall quote without stint.

London General Board of Health, p. 19 *to* 21,—"So perverse had been the former practice in respect to house-cleansing, that when water-closets were introduced, and when it might have been conceived that the ordure removed from sight would be immediately conveyed from the premises, it was only accumulated in a cesspool beneath them. A large proportion of the best houses in this metropolis have cesspools provided beneath, and when one has been filled up another has been opened, until much of the site is thus occupied. During the first labours of the General Board of Health much illness prevailed amongst the clerks, until on one occasion foul smells arising more severely than had been before noticed, the state of the foundations was examined, when it was discovered that there were two large cesspools immediately beneath the Board's office. This is the description of houses of which it is generally reported by house agents and others that they are well drained and in good condition; but it may be advised that it is absolutely unsafe to take any house without a thorough examination of the site beneath it, nor when

any cases of fever, typhoid or gastric, have occurred amongst persons living in the lower offices of a house, is it safe for others who value their own health to remain in the premises without such examinations, nor until the cesspools are removed. In some of the towns visited, where the practice of using cesspools has been long in operation, and where the sub-soil is becoming wholly saturated with excrementitious matter, it has already become very difficult to find a spot of earth capable of receiving further percolations. In Mr. Lee's Report on Reading, (p. 48,) Mr. Billing, the borough Surveyor, says: "That is already the case in one or two instances that I know, where a whole garden is a cesspool. Ground cannot be found in some places from which the night-soil will be absorbed and pass away. I know several cases of actual death, and others of disease, arising from each of the causes."

"In all these closed recepticles, whether fixed or moveable, decomposition is always in progress, commonly through all the chemical changes, and no effectual trap exists nor can reasonably be expected to succeed, in popular use, that will prevent the escape of noxious gases."

"From these magazines, miasma are extensively liberated and diffused, particularly in those barometric states of the atmosphere when the air is lightest; a state when the bodily strength is most depressed, and when the system is most susceptible to any extreme cause of disease. In districts which are in a low sanatary condition, extraordinary changes in the weather are often foretold by the emission of worse stenches than usual from drains and cesspools."

"Mr. Charles Oldfield, a builder of the highest class of houses, at the West end of the metropolis, thus describes his practice in relation to them: "I am frequently called upon to examine houses were they say they are oppressed by unpleasant smells. Some time ago, I was called upon to examine a house in one of the principal streets of London, belonging to a gentleman of distinction, who was about to abandon it in consequence of the unpleasant smells which were continually arising. He was particularly annoyed, because this smell arose in the greatest strength whenever he had parties; the drains had been opened, and there was no lodgement of soil in them. People commonly imagine that when they get rid of the soil they have got rid of the stench; they do not see, and do not conceive the effect of the foul air, which is so much lighter than atmospheric air that it escapes when the atmospheric air would not. On examining the drains of his house I found that they were imperfect, and that the foul air filtered through them. Whenever he had a party there was a stronger fire in the kitchen, and stronger fires in other parts of the house, and the windows and the external doors being shut, and a greater draught created, larger quantities of the foul air from the sewers rose up. These stenches arise in the greatest strength in private houses when the doors and windows are closed, the fire and column of light air in the chimney being at work."—*Vide Sanitary Report*, 1842.

Probably no capital in Europe is cleaner on the surface of its streets than Paris, where the cesspools are the most carefully constructed, and covered. It is, for the most part, well paved, and the surface of the streets

well cleansed; the atmosphere is comparatively free from visible smoke, but the superior cleanliness only renders the emanations from the cesspools the more distinctly and offensively perceptible. There are few who have visited that city who have not experienced, even in the finest streets and most sumptuous hotels, a peculiar and almost indescribable sensation from the offensive atmosphere around. It is felt in the court-yard, but it is produced in the greatest force on some staircase, passage, or landing leading from a common water-closet. It is caused by emanations from the foul cesspool into which all the refuse of the establishment is passed, and from which the dangerous gases of decomposition force their way through the whole atmospheric space around. To set open doors and windows is of little avail; that does not bring relief, the sensation remains. The refuse must be removed at once if there is to be safety or health; and such removal will be economical as well as healthful."

The 50th Report of the London Fever Hospital (for the year ending 31st December, 1851) contains the following description of the principal fever localities:

"The localities from which the patients have been sent extend over nearly every part of the metropolis; but by far the largest number have been received from the Holborn district. No fewer than 211 patients (out of 877 received in 1851) have come from courts and alleys on the Eastern side of Gray's-inn-lane, such as Tyndall's buildings, Pheasant-court, &c. In several instances 10 or 12 of these have been received from a single house, and in one instance as many as 20. Thus it appears that one side of a single street, with the

courts that branch off from it, have afforded nearly a fourth part of the total number of patients admitted during the year; but to this number should be added 50 more persons, who were removed to the hospital from the adjoining courts in Saffronhill; so that, in fact, this circumscribed spot has supplied the hospital with nearly one-third of its total number of patients. When the state of these fever nests is considered, this result will appear no matter of surprise; in Tyndall's buildings and the adjoining courts, for example, the floors of the cellars are some feet *beneath the main sewer*, so that the *drainage of the houses* is *impossible;* the privy and water-butt are commonly both together in the cellar; heaps of dust and decomposing matter are accumulated *within* the houses,—and in the whole of this locality overcrowding is carried to such an excess, that commonly three or four families occupy a single room, into which it is no unusual thing for 20 persons to be huddled together; one patient, indeed, stated, that, in the room in which he lived 27 persons lived by day, and slept at night."

Page 24,—"No one seemed aware of the inevitable effects of the percolation of liquid filth in the soil upon the wells, from which many houses derive their supply of water. The effect is indeed for a time disguised by the power of certain soils to absorb a portion of organic matter, and to effect the decomposition of much more, so that the result appears in the form of a nitrate of lime or other base. Nitrates are very commonly found in the well-water of towns, and doubtless owe their origin to the decomposition of organic liquid filtering through the soil. As the soil becomes more completely

saturated, the contamination of the water becomes more evident to the senses, till at last the wells are abandoned. In one district where many houses have been drained with tubular drains, and cesspools abolished, an evident improvement both in the appearance and taste of their well-water has been frequently noticed by the inhabitants with some surprise; it was a result, from the abolition of cesspools, for which they were not prepared.

Page 25, Vide report on Water supply, p. 91,—"Dr. Angus Smith examined a number of wells both in Manchester and London, and found nitrate in nearly all. When in considerable quantity they give to the water a very unpleasant taste."

"On the subject of the pollution of wells from the permeation of the contents of cesspools, Mr. Quick made the following statement in evidence before the Health of Towns Commission: 'Within a few days we have had an instance at Battersea of permeation of the cesspools in six new houses. They were supplied with water from springs sunk to the same level as the cesspools. As the springs were lowered by the consumption of the water, it was found, to the surprise of the inhabitants, instead of coming up clearer it was more discoloured, by the equalization of the water levels. One of the inhabitants, a baker, who drew harder than the rest, applied to the company to lay on the water, (to supply him with good water,) giving me to understand that the people began to complain of the quality of his bread, the cause of which he could not make out, except it arose from the quality of the water, which somehow or other, was very bad: all his neighbours who drew from

the same spring complained that the water was very bad. The cause was, on examination, undoubted."

We know all this; well-water in Charleston, which but recently was potable and answered for culinary purposes, has become unfit, *even for ablution.* Privy vaults should be *impermeable.*

London General Board of Health, January, 1852, p. 1, 2, 3, 4, 5 and 82,—Minutes of information collected in respect to the Drainage of Land, forming the sites of towns, to Road Drainage, and the Facilitation of the Drainage of Suburban Land.

"Town drainage is two-fold,—foul water drainage and simple water drainage. The first comprehends sewerage as the term is now commonly used; that is, the removal from within dwellings or from their immediate neighbourhood of all solid refuse which can be carried off by water. The second—simple water drainage—is the removal from the sites and suburbs of towns of superfluous water, causing dampness, whether such water be derived from land spring or rain-fall."

"So general is the latter or simple-water drainage neglected, that it appears from the late sanitary investigations that in town districts which are called drained, the foundations of the houses are very generally damp from the retentiveness, or the water-bearing power, of the soil in which they are built. Water rising from a damp foundation by absorption renders the floors and the walls damp, in proportion to the absorbent nature of the materials of which they are constructed. When experienced medical officers see rows of houses springing up on a foundation of deep retentive clay, inefficiently drained, they foretel the certain appearance

among the inhabitants of catarrh, rheumatism, scrofula, and other diseases, the consequence of an excess of damp, which break out more extensively and in severer forms in the cottages of the poor who have scanty means of purchasing the larger quantities of fuel, and of obtaining the other appliances by which the rich partly counteract the effects of dampness. Excess of moisture is often rendered visible in the shape of mist or fog, particularly towards evening. An intelligent medical officer took a member of the Sanitary Commission to an elevated spot from which his district could be seen. It being in the evening, level white mists could be distinguished over a large portion of the district. "These mists," said the officer, "exactly mark out and cover the seats of disease for which my attendance is required. Beyond these mists I have rarely any cases to attend but midwifery cases and accidents." Efficient drainage causes the removal, or at least a great diminution of such mists and a proportionate abatement of the diseases generated or aggravated by dampness."

"After houses built in the manner described have been inhabited for some time, and especially if crowded, fevers of a typhoid type are added to the preceding list of diseases, in consequence of emanations from privies and cesspools. The poisonous gases, the product of decomposing animal and vegetable matter, are mixed with the watery vapours arising from the excessive damp, *(such vapours being now recognized as the common vehicle for the diffusion of the more subtle noxious gases,)* and both are inhaled night and day by the residents of these unwholesome houses. A further consequence of the constant inhalation of these noxious

gases, which have an extremely depressing effect, is inducing the habitual use of fermented liquors, ardent spirits, or other stimulants by which a temporary relief from the feelings of oppression is obtained."

I pause to say, that yellow fever has never been known to prevail as an epidemic in Charleston during *very dry* seasons, and consequently a *moist atmosphere* must be the *common vehicle* for the *diffusion* of this *subtle atmospheric poison.*

" The plain surplus land water, whether from upland springs or from the rain-fall in garden ground or in the space uncovered by houses or by the paving of yards or streets, will remain to be specially provided for, and it is deemed will be most economically carried off by arrangements of permeable pipes, on the same principle as those used for the drainage of land under cultivation."

" The sanitary interests also of the locality urgently demand attention to the drainage of its suburban land; for excess of moisture most powerfully influences the local climate both as to dryness and temperature, as shewn in the report of the Metropolitan Sanitary Commissioners under the following heads:

1. Excess of moisture, even on lands not evidently wet, is a cause of fogs and damps.

2. Dampness serves as the medium of conveyance for every description of matter that may be evolved, and adds to the injurious effects of such matter in the air: in other words, the excess of moisture may be said to increase or aggravate atmospheric impurity.

3. The evaporation of the surplus moisture lowers temperature, produces chills, and creates or aggravates

the sudden and injurious changes or fluctuations of temperature, by which health is injured."—*Vide Sanitary Report*, 1842, *pp.* 80, 92 ; *Second and Third Metropolitan Sanitary Reports; and postea, pp.* 66, 69.

"Where there is a large acccumulation of surplus moisture, having animal or vegetable matter in suspension or solution, the injury to the public health is so direct and considerable as to amount to a nuisance requiring authoritative intervention. The evils thus arising, which are found in the greatest intensity in low-lying town districts, in valleys near rivers, or on sites below high-water mark, have been exemplified in the General Sanitary Report and also in the Second Report of Metropolitan Sanitary Commissioners. The inhabitants of drier districts are often afflicted with marsh diseases from the ill-drained lowlands; thus, after the prevalence of easterly winds over the Essex and Kent marshes, cases of marsh fever and ague are found scattered throughout the whole extent of the metropolis."

"Every one must have remarked on passing from a district with a retentive soil to one of an open porous nature,—respectively characterized as cold and warm soils,—that often whilst the air on the retentive soil is cold and raw, that on the drier soil is comparatively warm and genial. The same effect which is here caused may be produced artificially by providing for the perfect escape of superfluous water by drainage, so as to leave less to cool down the air by evaporation. The reason of this difference is two-fold. In the first place, much heat is saved, as much heat being reqired for the vaporization of water as would elevate the

temperature of more than three million times its bulk of air one degree. It follows, therefore, that for every inch in depth of water carried off by drains which must otherwise evaporate, as much heat is saved per acre as would elevate eleven thousand million cubic feet of air one degree in temperature. But that is not all. Not only is the temperature of the air reduced, but its dew point is raised, by water being evaporated which might be drained off; consequently the want of drainage renders the air both colder and more liable to the formation of dew and mists, and its dampness affects comfort even more than its temperature. It is easy then to understand how local climate is so much affected by so much surplus moisture, and so remarkably improved by drainage. A farmer being asked the effect on temperature of some new drainage works, replied that all he knew was, that before the drainage he could never go out at night without a great-coat, and that now he could, so that he considered it made the difference of a great-coat to him. Mr. William Tilley, head gardener to the Duke of Portland, stated to Mr. Lee, Superintendent Inspector of the Board, that the local climate was improving, that in consequence of the drainage of part only of the district there had been a rise of one degree in the temperature of the whole district on the average of ten years. As the evaporation is greatest in the summer, the rise of temperature is greatest at that season. Dr. Madden has observed a difference of 6½ degrees in the summer temperature of drained and undrained land, and of course there would be a corresponding difference in the temperature and dampness of the air. It appears, therefore, that an effect similar to

that of removal to a more genial climate may be produced by draining, which is itself a profitable employment of capital, both to the owners and occupiers of the soil.

Page 69,—Queries issued at the request of the Metropolitan Sanitary Commissioners by the Right Honourable the Earl of Carlisle regarding the Drainage of Land; with answers to the same by several persons, (among whom was Lucias Henry Spooner, Esqr., Balmaca House, Loch Alsh.)

Page 82, (Mr. Spooner,)—"Apart from the benefits derived in an agricultural view, drainage on an extensive scale must ameliorate the climate of districts in which it is practised, and, in a great measure, tend to purify their atmosphere."

"Water that is stagnant, shallow water, and water mechanically separated, as it is when held in soil, is far more susceptible of evaporation than when in motion as a river, or combined in a large body as in a lake or sea; and it is a well known fact, that evaporation is always accompanied with a diminution of the temperature of objects from which it takes place. Now, the constant motion in which water is kept by drainage, and its removal at such a depth below the surface as to prevent its being acted upon by the sun's influence, must of necessity also prevent excessive evaporation, with it concomitant reduction of temperature."

"Again if ammonia and other gaseous products, the result of animal and vegetable decomposition, are, as there is every reason to suppose they are, the origin of miasma, and the fruitful source of fevers, their retention near the surface will be greater in proportion to the

amount of water, the denser absorbent existing in or supplied to the atmosphere immediately surrounding that surface."

Penny Cyclopædia, vol. 21, p. 319,—"Mr. Fuller, a medical gentleman, in presenting a plan for ventillating sewers to the Parliamentary Committee of 1842, stated, that of all the cases of severe typhus that he had seen, eight-tenths were in houses either untrapped from the sewers or which being trapped were situated opposite to gully holes; and he mentioned cases in which servants sleeping in the lower rooms of houses so situated were invariably attacked with typhus fever. Instances were also adduced in which it had been found necessary, either to trap or to remove gully holes in the vicinity of butcher's shops, owing to the injurious effect of the effluvia upon the meat."

From the foregoing extracts it is very apparent, that not only surface but *subsoil* drainage of the squres must be very conducive to the health of cities.

WATER.

Dempsey, Art. 332,—"The superior quality of rain water in respect to its softness, as compared with water from all other sources, renders it exceedingly desirable in an economical view, that all the supply desirable from this source should be carefully collected and preserved. In towns this water is commonly wasted, or at least allowed to subserve only the inferior purpose of assisting the flow of the drainage. Yet the quantity which might by efficient arrangements be commanded of this superior water is by no means insignificant. The roof of a house of the average dimensions of 20 feet square,

presenting a plane surface of 400 square feet, receives at least 800 cubic feet of rain water annually, or about 4800 gallons. If well constructed and capacious gutters are provided, this quantity may be collected with little loss from evaporation, and will form a reserve stock for such special household purposes as it is peculiarly adapted for."

The only precaution necessary in Charleston is, not to admit the water into the cistern till the roof has been well washed by the rain. The rain that falls in Charleston per annum, greatly exceeds the quantity given above for a similar roof.

Mr. John Lee, of Cincinnati, in a long communication to the Gazette, states as a fact, that "cholera never becomes epidemic in any district or city where rain or pure soft water is used;" and supports his statements by many important facts. He also states that during five years past, not one well authenticated fatal case of cholera has occurred where rain water was exclusively used.

PRIVIES.

Dempsey, Art. 176 and 177,—"During the putrefaction of the matters in sewers and vaults, the ammonia they contain (and which is one of their useful constituents) is disengaged; and if this process takes place in the open air, it is of course mingled with the atmosphere in the form of carbonate of ammonia, and leaves the sewage or feces in a less valuable condition. Now this volatile carbonate of ammonia, may be fixed in many ways. Thus, says Liebig: Gypsum, chloride of calcium, sulphuric or muriatic acid, and superphosphate

of lime, are substances of a very low price; and if they were added to urine until the latter lost its alkalinity, the ammonia would be converted into salts, which would have no further tendency to volatilize. When a basin, filled with concentrated mutriatic acid, is placed in a common necessary, so that its surface is in free communication with the vapours issuing from below, it becomes filled, after a few days, with crystals of muriate of ammonia. The ammonia, the presence of which the organs of smell amply testify, combines with the muriatic acid, and loses entirely its volatility, and thick clouds or fumes of the salt, newly formed, hang over the basin. In stables the same may be seen. The ammonia escaping in this manner is not only lost, as far as our vegetation is concerned, but it works also a slow, though not less certain, destruction of the walls of the building. For, when in contact with the lime of the mortar, it is converted into nitric acid, which dissolves gradually the lime. The injury thus done to a building by the formation of soluble nitrates has received (in Germany) a special name—salpeterfrass (production of soluble nitrate of lime.) The ammonia emitted from stables and necessaries is always in combination with carbonic acid. Carbonate of ammonia and sulphate of lime (gypsum) cannot be brought together at common temperatures, without natural decomposition. The ammonia enters into combination with the sulphuric acid, and the carbonic acid with the lime, forming compounds destitute of volatility, and consequently of smell. Now, if we strew the floors of our stables, from time to time, with common gypsum, they will lose all their offensive smell, and none of the ammonia can be lost, but will be retained in a condition

serviceable as manure. (Mohr.) "Chemistry in its application to Agriculture and Physiology," by Justus Liebig. Edited by Drs. Playfair and Gregory. 4th edition, 1847: p. 189."

"Chemistry thus supplies us with the means by which all the offensive and detrimental properties of the sewage may be suppressed, and all the useful properties safely retained. There is evidently no necessary reason why a tank or receptacle in which the sewage or feces is collected and stored, should be, in any respect, more disgusting to the senses, or injurious to the health of human beings, than a reservoir of the purest water."

Neutralizing Offensive Odours.—"The North British Agriculturalist furnishes a statement of Lindsey Blyth, in relation to a very successful experiment for destroying a most offensive smell in a stable, arising from the decomposition of urine and dung. He tried the mixture of Epsom salts and plaster of Paris, (gypsum,)—"the most wonderful effects followed and the stable-keeper was delighted." Previously the stable was damp and unwholesome; and if closed for a few hours, the ammonical vapours were suffocating. After sprinkling the sulphates underneath the straw, and along the channel of the drain, the smell disappeared, and even the walls became drier. He recommends as an economical preparation for this purpose and for sewers, magnesia limestone dissolved in sulphuric acid, (forming sulphate of magnesia or Epsom salts,) with a portion of super-phosphate of lime (made by dissolving bones in sulphuric acid)—these, at the same time that they retain the escaping ammonia, also add greatly, by their own presence to the value of the manure."

Professor William Hume recommends white vitriol (sulphate of zinc) for privy use, as most convenient; two or three table-spoonfulls scattered over the vault that contains sufficient water to dissolve it, or dissolved in water and then sprinkled over the vault, will render it innoxious. Repeat the operation for several days at first, and periodically afterwards, and the privy will be no longer a nuisance; which, particularly in a confined place, causes disease, loss of time, and consequently money. The cost of the white vitriol is not worth estimating in comparison. The very comfort of its use is worth greatly more than its cost. It should be used in all privies, public and private. Farmers will find it greatly to their interest to take, each, a number of privies under their charge; in so doing the health of the city will be promoted, and the returns of their farms greatly increased. They will be compensated by a very considerable interest on the outlay, without suffering in the least from disgusting odours, if properly managed. White vitrol is not costly, and the city authorities may make it less so, by furnishing a quantity which the people may purchase at cost; or some other article still cheaper may be substituted. Be careful to use a good article, for if the first trial fails, with many persons, it will not be repeated. In building permanent privies all over the Upper Wards, they may be so constructed as to facilitate this business, with very little or no additional expense.

Dempsey, Art. 154,—" The value of manures as promoters of vegetation is known to result from their possession of the essential element, nitrogen, in the form of ammonia, with the subordinate properties of alkalis,

phosphates, and sulphates. Now, the experiments of Boussingault and Liebig have furnished us with the means of estimating the quantity of nitrogen contained in the excrement of a man during one year, at 16.41 lbs., upon probable data, and also that this quantity is sufficient for the supply of 800 lbs. of wheat, rye or oats, or of 900 lbs. of barley. "This is much more than it is necessary to add to an acre of land, in order to obtain, with the assistance of the nitrogen absorbed from the atmosphere, the richest crops every year. By adopting a system of rotation of crops, every town and farm might thus supply itself with the manure, which, besides containing the most nitrogen, contains also the most phosphates. By using, at the same time, bones and lixiviated ashes of wood, animal excrements might be completely dispensed with on many kinds of soil. When human excrements are treated in a proper manner, so as to remove the moisture, without permitting the escape of ammonia, they may be put into such a form as will allow them to be transported even to great distances." (Liebig.) Making reasonable allowance for the reduced quantity produced by children, we shall be safe in assuming the nitrogen thus resulting from any amount of population to be equal to the supply required for affording 2 lbs. of bread per diem for every one of its members! Or assuming an average of 600 lbs. of wheat to be manured by each individual of the population of London; and taking this at two millions, for a rough calculation, the manure thus produced is sufficient to supply the growth of wheat of a total weight of 1200 millions of pounds, or 535,714 tons.

END.

Plate 2.

Fig 1

Fig 2

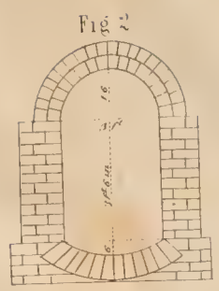


Fig 3

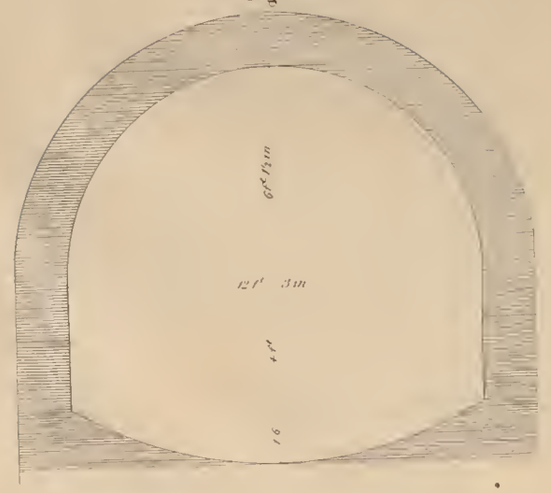


Fig 4

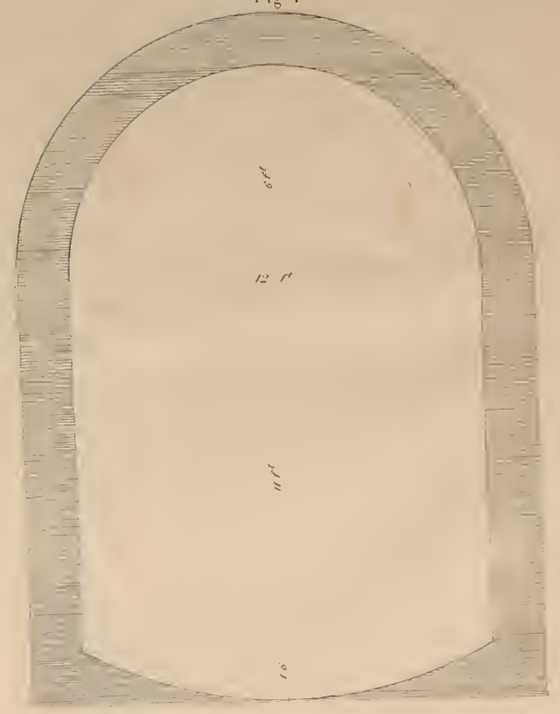
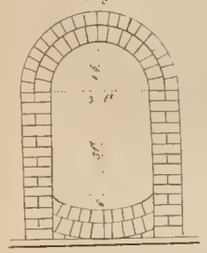


Fig 5



The Sections of Sewers are all drawn on the same Scale

Fig 6

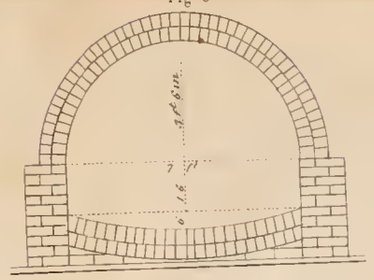


Fig 9

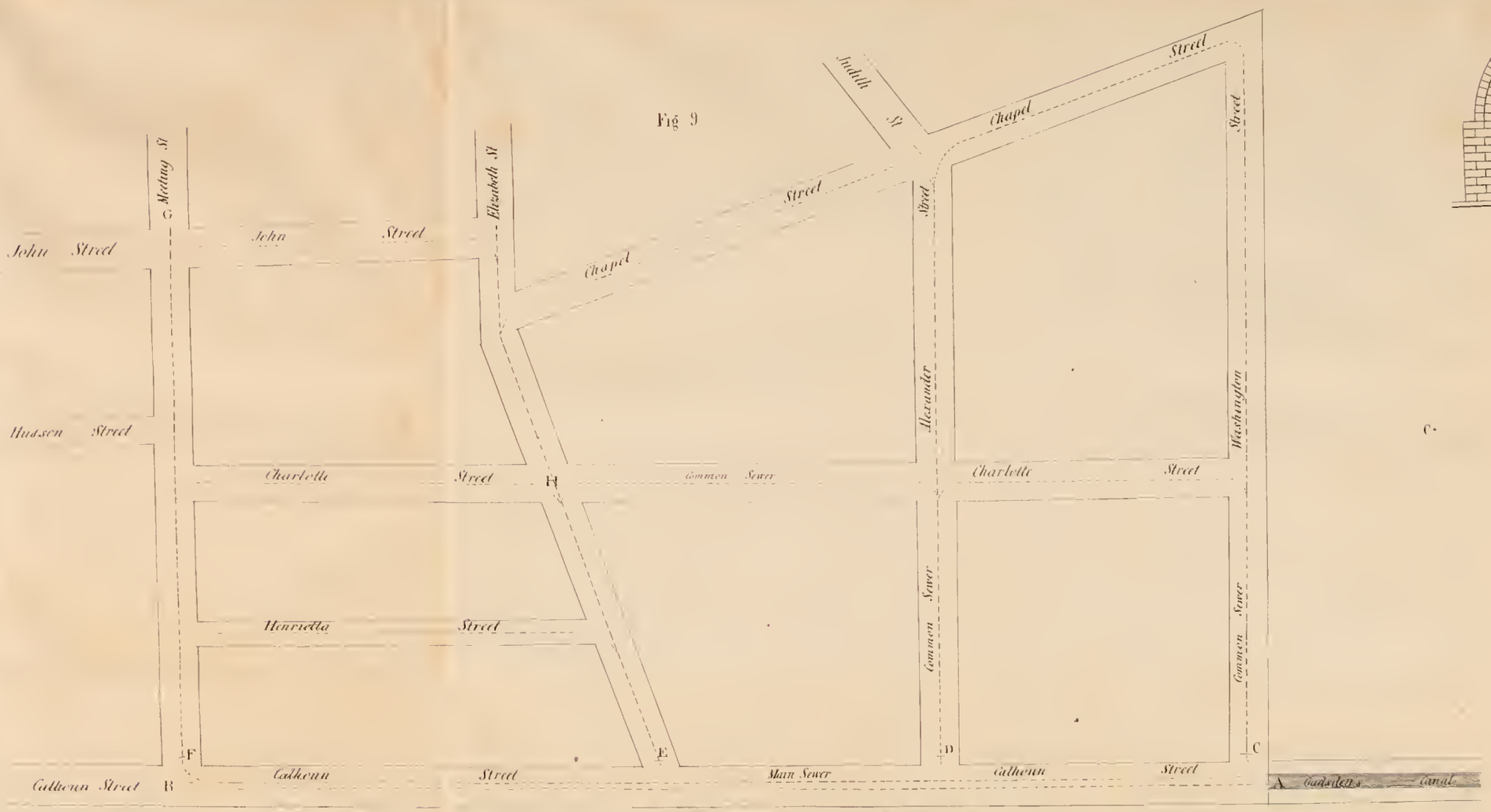


Fig 7

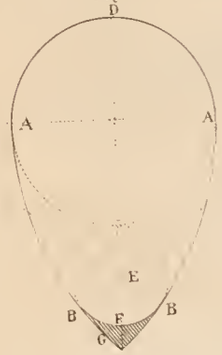


Fig 8

Sewer Ward of Charleston

Scale 20 feet per Inch

W. Keenan, Lith. Charleston S.C.